FILE COPY FOREST INSECT LABORATORY, UNIVERSITY OF CALIFORNIA, BERKELEY, CALIFORNIA.

612.
428.2

UNITED STATES DEPARTMENT OF AGRICULTURE

BUREAU OF ENTOMOLOGY AND PLANT QUARANTINE

Project | Date | Author

TITLE

A METHOD OF CORRECTING BARK BEETLE SURVEY DATA OBTAINED PRIOR TO COMPLETION OF ATTACK PERIOD

by
James C. Evenden
Senior Entomologist

JHM
MLL
JEP
ASW
CPF
RCJ
PCJ
ESS

Forest Insect Laboratory
Coeur d'Alene, Idaho
July 11, 1939

SUBJECT—

INDEX NO.—

U. S. GOVERNMENT PRINTING OFFICE 8—0742

A METHOD OF CORRECTING BARK BEETLE SURVEY DATA OBTAINED PRIOR TO COMPLETION OF ATTACK PERIOD

FOREWORD

The first step in preventing the development of destructive epidemics of the mountain pine beetle (Dendroctonus monticolae Hopk.) is recognized as an adequate annual program of detection surveys. It is only from such surveys that potentially dangerous situations can be recognized while in their early stages, and artificial control instituted at a time when the greatest benefits will be derived at the lowest cost of operation. Obviously the value of these surveys rests in the accuracy of the data obtained. Infested areas must be properly sampled, and data taken that will depict the actual status of the current year's infestation, as well as permit a forecast of its subsequent trend.

In meeting the requirement of accuracy the most difficult problem is to determine the number of trees that are attacked after the survey of a specific area has been completed. This condition results from the prolonged attack period of the mountain pine beetle, which extends from June until September or sometimes later, varying with seasonal conditions. Surveys conducted during this attack period will only be as accurate as the percentage of the total attacks that have occurred. The importance of these subsequent attacks is variable and will depend upon the time of the survey and the occurrence of unseasonal temperatures.

Although the relation of this prolonged attack period to survey data has been recognized for years, its maximum potentials have not been fully appreciated. This lack of full appreciation was strengthened by the

many outstanding examples of the accuracy of our surveys, which lead to the belief that the subsequent attacks were offset by compensating factors and that they did not materially increase the original estimate of infested trees. Such compensation could come from (1) counting light attacks that were finally "pitched out", (2) the natural tendency on the part of survey men during the early years of our surveys to include attacked trees that were just outside of strip line boundaries, (3) normal tendency to slightly overpace in rough country, which gives an inflated estimate of the number of infested trees, (4) a seasonal variation in the percent of the bole that is attacked, as when the upper portion of the bole is available the late attacks will often occur as "fill in" of previously recorded trees and not as additional attacked trees, (5) and of course the late attacks of the previous season, that are recorded as infested trees during the first part of the survey but from which the beetles emerge during September. All of these factors tend to cause an overestimation in the number of infested trees which in many instances was compensated by the late attacks, causing the final figures to be quite accurate. Although improvements in our surveys have practically eliminated those errors resulting from operating technique, those associated with seasonal variations will continue to play a part in the final summation of bark beetle survey data. Although a complex problem, it is now appreciated that the importance of these subsequent attacks is sufficient to warrant their proper evaluation in the interpretation of survey data.

THE PROBLEM

Were it not for the element of time, an easy solution would be to postpone the institution of survey programs until the attack period is over. However, the portion of the field season remaining would be so short that in most cases the projects could not be completed. Obviously the later such surveys can be instituted the less important the late attacks will become. In the past it has been necessary to institute the survey program adopted by the Coeur d'Alene Laboratory rather early in August in order to complete the work prior to the end of the field season. Furthermore, as in this region fall control is in most instances more advantageous than spring projects, it is desirable to conduct these surveys sufficiently early to permit arrangements for the institution of such projects by the 15th of September.

Permanent sample strip or plots examined at ten-day intervals, if representative of conditions, will establish the percent of the current season's attacks that have occurred by the date of examination and permit a fairly accurate correction to be applied to previously obtained data. Although this method has certain mathematical objections, the primary disadvantage rests in the size of the sample that would be required to provide significant data. In dealing with severe infestations of the mountain pine beetle distributed over large areas of lodgepole pine, with a number of attacked trees per acre, representative data could be obtained from a few sample strips. However, in dealing with outbreaks of this insect in western white pine, where the infestation varies from .10 to as much as 1.00 tree or more per acre, it is apparent that a much larger sample would

be required. Under such conditions, where the subsequent new attacks will in most cases be less than the total number of infested trees indicated by the actual survey, the check sample would need be equal in area to the original survey if representative data were obtained. The use of this method of correcting survey data is limited by the labor required for obtaining adequate check data, as well as the inconvenience of returning to the area in question for periodic examination.

The possibility of developing a chart or graph portraying the trend of the seasonal attack period as advanced by Keen and Johnson* for the western pine beetle has been studied. The seasonal variation encountered with mountain pine beetle infestation in white pine would make the use of such graphic methods somewhat difficult. However, as more data become available it is possible that some modification of these methods may be applicable to this region.

With present information it would seem that the most feasible solution for this problem will be from data taken at the time of the survey. Although the obtaining of such information with nontechnical men is not an easy task, a tentative plan has been devised, which is intended to eliminate the present objection to August and early September surveys. During the 1938 season a similar plan was tested. Although based upon the same entomological foundation as the method proposed in this paper, it was not satisfactory. These objections are believed to have been eliminated in the following tentative solution.

---

* Unpublished office reports - Estimating pine beetle losses during period of attack" by F. P. Keen, February 6, 1931, and "Correction factors for use in estimating total seasonal bark beetle losses in California" by P. C. Johnson, February 5, 1935.

A POTENTIAL SOLUTION

CORRECTING EACH DAY'S DATA BY A PERCENTAGE BASED UPON THE NUMBER OF TREES ATTACKED DURING SUBSEQUENT SEVEN-DAY PERIODS

This method, although somewhat complicated in its application, satisfies the requirements of simplicity as far as obtaining field data, as it is based upon the occurrence of newly attacked trees with egg galleries of not more than 2 inches in length. All infested trees recorded on each sample strip are listed as old or new attacks, the determination being based upon an adequate basal examination which when necessary includes all four sides of the tree. The old attacks have egg galleries of more than 2 inches in length, while the new have galleries of 2 inches or less in length. In classifying new attacks the length of the longest gallery is the determining factor and not the average. Galleries of not more than two inches in length, when found during the early part of the season, depict attacks that are not more than one week old. During the later part of the season, when the daily period of activity temperatures is reduced, two-inch egg galleries may represent attacks of two or more weeks' duration.

Data taken on any one day can be corrected by a figure derived from the number of new attacks that occur during the subsequent week, and this result can in turn be corrected by similar data from the second seven-day period, and so on, throughout the duration of the attack period. An example of the application of this method would be as follows: data taken on August 1 indicate an infestation of .5 tree per acre for the area covered on that date. During the subsequent seven days of the survey,

August 2-8 inclusive, the data obtained show that one-half of the infested trees recorded had been attacked during that period, which indicated a 50 percent increase in the infestation. Therefore, although on August 1 the .5 tree per acre represented the total infestation for that area on that date, in order to obtain a figure depicting the total infestation as on August 8 it would be necessary to increase the original figure by 50 percent, giving a total of .75 tree per acre. During subsequent weeks it would be necessary to apply further corrections for additional new attacks. The correction factor used is the percent that the new attacks are of the old, and not the percent that the new attacks are of the total. For example, if during the week of August 2-8, the data obtained indicated 100 old attacks and 50 new attacks, the correction factor to be applied to August 1 data would be 50 percent, and not 33 percent.

To obtain the percentage that the new attacks are of the old, a complete week's data are used, rather than the subsequent seventh day, as more reliable results are obtained. As the new attacks are from one to seven days old it is entirely possible for some of them to have been a part of the total infestation recorded for the area surveyed on August 1, and to which the correction is applied. If the new attacks were equally distributed, it would be possible for 85.2 percent of new attacks recorded on any one day to have been a part of the infestation recorded the previous day. The percentage of this potential overlap of new attack data decreases each day so that on August 7 the chance of new attacks having been a part of the infestation recorded for August 1 would be but 14.2 percent, and on the last day, August 8, there would be none whatever.

Although this possibility is recognized this potential overlap is offset by the fact that on August 2 there is the period August 3-8 inclusive during which more new attacks could occur. To compensate for this possibility, the new attacks that occurred during the six previous days are used, which provides a moving weekly percentage of new attacks.

It will be seen that this method is based upon the premise that the seasonal history of the mountain pine beetle will be the same throughout the area surveyed. As far as the practical application of this method of correcting survey data is concerned, this will in most cases be true, however it is recognized that situations will exist where data taken from one area will not be applicable to another.

The formula for the application of the weekly correction factors can be shown somewhat graphically as follows:

To correct survey data taken on								
Aug. 1 -	Infestation shown	+	Percent which the new attacks occurring during the period of Aug. 2-8 are to old attacks	+	Percent which the new attacks occurring during the period of Aug. 9-15 are to old attacks	+	To end of activity period	= X
Aug. 2 -	Infestation shown	+	Percent which the new attacks occurring during the period of Aug. 3-9 are to old attacks	+	Percent which the new attacks occurring during the period of Aug.10-16 are to old attacks	+	To end of activity period	= X
Aug. 10 -	Infestation shown	+	Percent which the new attacks occurring during the period of Aug.11-17 are to old attacks		Percent which the new attacks occurring during the period of Aug.18-24 are to old attacks	+	To end of activity period	= X

It will be seen that in arriving at a correction factor for each successive day's data the running weeks are obtained by dropping a day from the first of the period and adding one to the end. This procedure is simplified through the use of the form (table I) provided for recording the data obtained by the survey crew, and from which the correction factors are easily derived.

These forms will accommodate only 14 complete day's data. When additional sheets are required the figures are carried forward as though the second sheet was but a part or a continuation of the first. The first date on the second sheet will be the 15th day of the survey, although the first sheet will hold part of the data from the 15-20 day inclusive. On this form the number of old and new attacks recorded by the entire crew are shown separately for each day worked, in spaces opposite the date on which the data were obtained. It will be seen that although there is only one space for the first day's data, the number of spaces increases each day so that after the sixth day it will be necessary to record each day's data seven times. When no data are obtained zeros are placed in the spaces, but when no work is performed a line is used.

At the bottom of the blocks A, B, C, etc., there is a space for the total of the old and new attacks and directly below a space in which the percent which the new attacks are of the old is shown. This figure depicts the percent which the infestation increased during the past seven days and is used to correct data taken, or, as the case may be, corrected 8 days previously. As new attacks will of course occur during the second, third and fourth or more weeks of the survey, it is necessary

to use the correction factor obtained during these successive seven-day periods. The legends at the top of the seven-day blocks, A, B, C----G, in series of seven, permit a quick and correct selection of the correction factors to be applied to any one day's data. The legend to be used is shown in the date column opposite the date the data was taken. By using these legends the formula shown on page 7 is simplified as follows. For example, to correct data obtained on August 1, it will be seen that the factors A are to be used. The formula then becomes:

$$\left[\left[\text{August 1 data} + \text{Correction 1st A}\right] + \text{Correction 2nd A}\right] + \text{Correction 3rd A}\Big] =$$

Or to correct data obtained on August 6:

$$\text{August 6 data} + \text{Correction 1st F} + \text{Correction 2nd F} + \text{Correction 3rd F} =$$

By using the figures shown for illustration in table 1, a practicable application of the formula is shown. Assuming the data obtained on August 1 indicates an infestation of .80 tree per acre, we have

$$\left[\left[.80 \text{ tree per acre} + \text{1st A}\right] + \text{2nd A}\right] + \text{3rd A}\Big] =$$

$$.80 \text{ tree per acre} + 17\% + 13\% + .05 =$$

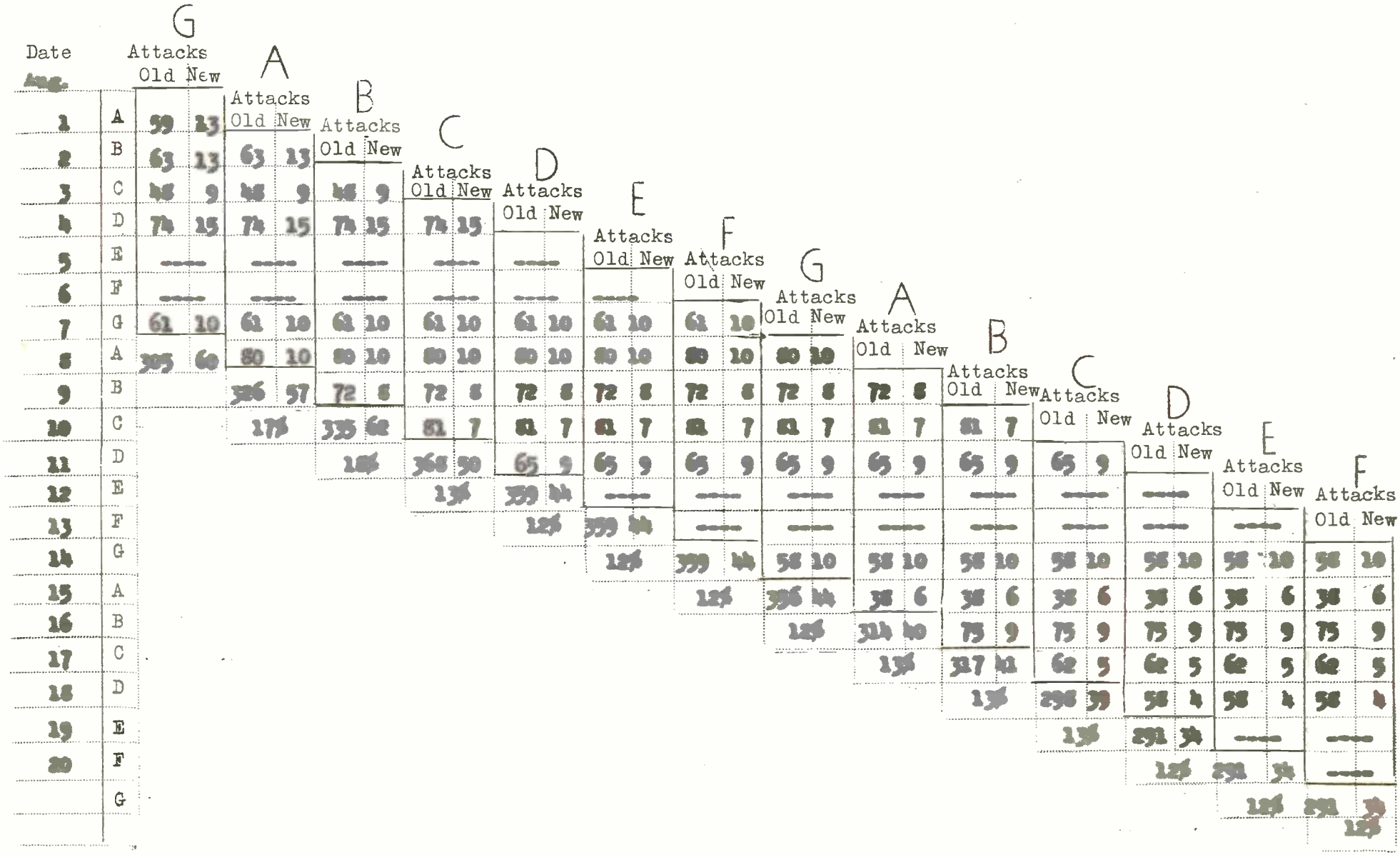
$$.80 \text{ tree per acre} + .14 + .12 + .07 = 1.13 \text{ tree per acre on August 22}$$

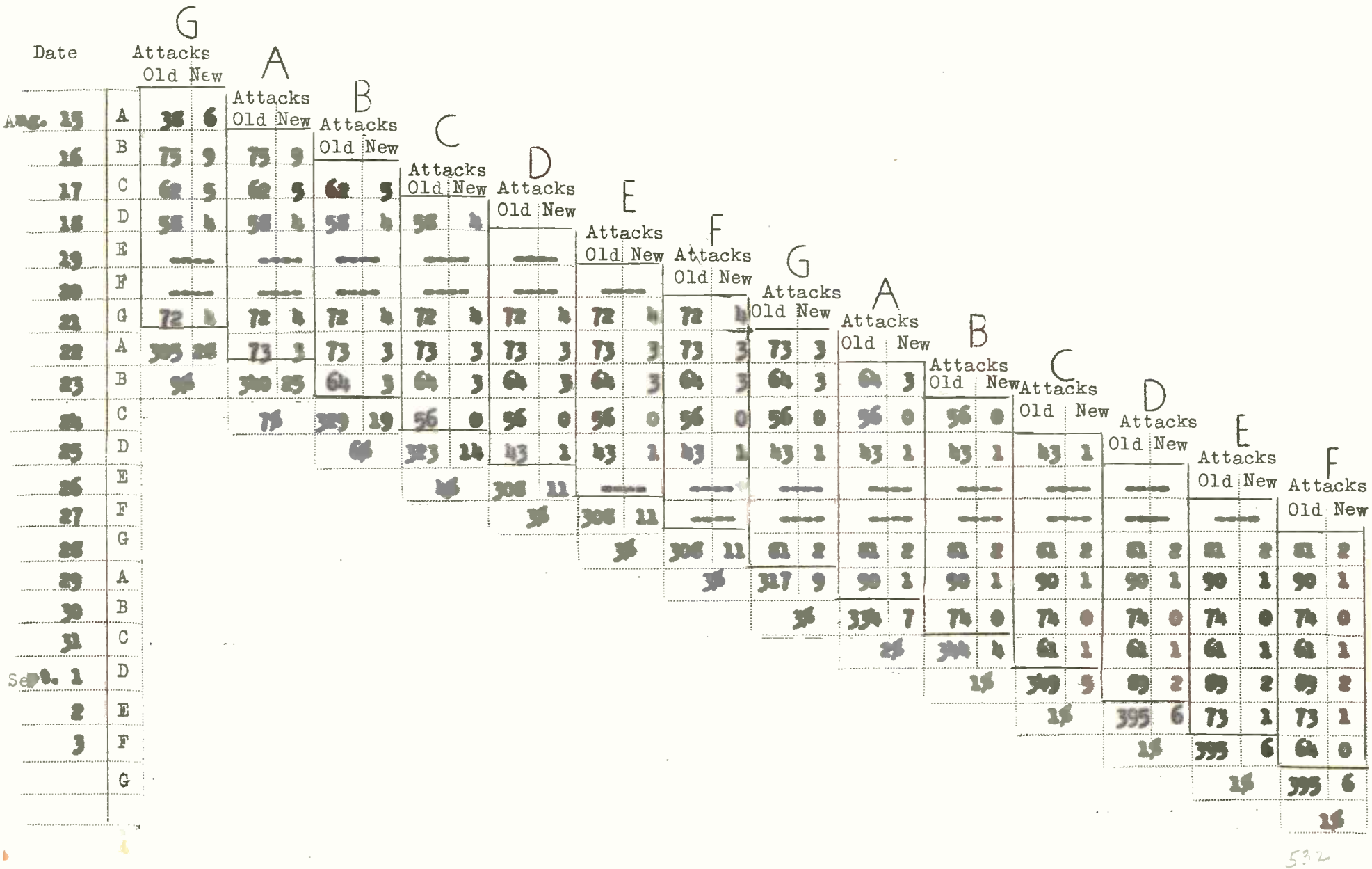
Although it is believed that this procedure offers a method for correcting survey data taken during the period of new attacks, there are physical and statistical objections to it. The greatest difficulty will be to determine the period over which these weekly correction factors can be applied, for as stated, during the later part of the season a 2-inch

egg gallery will represent an attack of more than a week's duration. This requirement will be met by the Bureau officer in charge of the operation, based upon his own observation relative to seasonal history developments, strengthened through data obtained by strip runners. Each strip runner records for all infested white pine encountered on his strip the brood stage at the base of the tree. These stages usually run in the following groupings: (Eggs), (Eggs-Small Larvae), (Eggs-Small Larvae-Large Larvae), (Small Larvae-Large Larvae), (Large Larvae-Pupae-New Adults), (Pupae-New Adults). From this information, which is also required for the proper interpretation of the survey data, it is believed that this officer will be able to establish the period to which these corrections are to be applied with acceptable accuracy. Obviously the use of these correction factors will only be necessary through the most active attack period, which for normal seasons will not last much longer than the 10th to 15th of September.

CONCLUSIONS

This method of correcting survey data obtained prior to the completion of the attack period will be tested during the 1939 season as a possible solution. It is realized that changes will no doubt be necessary, and it is possible that the plan can be discarded entirely in favor of a simpler and more efficient procedure. However it is considered as a necessary step in attempting to make our bark beetle surveys more accurate and of greater service.


Date
Aug.
G
Attacks
Old New
A
Attacks
Old New
B
Attacks
Old New
C
Attacks
Old New
D
Attacks
Old New
E
Attacks
Old New
F
Attacks
Old New
G
Attacks
Old New
A
Attacks
Old New
B
Attacks
Old New
C
Attacks
Old New
D
Attacks
Old New
E
Attacks
Old New
F
Attacks
Old New
1 A 59 23
2 B 63 13 63 13
3 C 46 9 46 9 46 9
4 D 74 15 74 15 74 15 74 15
5 E
6 F
7 G 61 10 61 10 61 10 61 10 61 10 61 10 61 10
8 A 305 60 80 10 80 10 80 10 80 10 80 10 80 10 80 10
9 B 326 57 72 6 72 6 72 6 72 6 72 6 72 6 72 6 72 6
10 C 175 335 62 81 7 81 7 81 7 81 7 81 7 81 7 81 7
11 D 185 368 90 65 9 65 9 65 9 65 9 65 9 65 9 65 9 65 9
12 E 136 359 44
13 F 125 339 44
14 G 126 339 44 58 10 58 10 58 10 58 10 58 10 58 10 58 10 58 10
15 A 125 336 44 38 6 38 6 38 6 38 6 38 6 38 6 38 6
16 B 125 334 40 75 9 75 9 75 9 75 9 75 9 75 9 75 9
17 C 135 317 42 62 5 62 5 62 5 62 5 62 5 62 5 62 5
18 D 135 296 39 58 4 58 4 58 4 58 4 58 4 58 4
19 E 135 291 34
20 F 125 291 34
G 125 291 34
125


Date
G
Attacks Old New
A
Attacks Old New
B
Attacks Old New
C
Attacks Old New
D
Attacks Old New
E
Attacks Old New
F
Attacks Old New
G
Attacks Old New
A
Attacks Old New
B
Attacks Old New
C
Attacks Old New
D
Attacks Old New
E
Attacks Old New
F
Attacks Old New
Aug. 15 A
16 B
17 C
18 D
19 E
20 F
21 G
22 A
23 B
24 C
25 D
26 E
27 F
28 G
29 A
30 B
31 C
Sept. 1 D
2 E
3 F
G